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TIMSS AND MINNESOTA: A STORY FOR POLICYMAKERS

On October 2, 2000, the National Education Goals Panel will release a compelling report about the results of Minnesota students' participation in the Third International Mathematics and Science Study (TIMSS). Minnesota students in 8th grade, unlike their counterparts elsewhere in the United States, performed at world-class levels in science. Their results, however, are only half the story. In addition, the report shows lessons for policymakers across the states about the conditions and policies that help attain internationally competitive levels of student achievement. The report is called *Minnesota and TIMSS: Exploring High Achievement in Eight Grade Science*.

The report–and this preview of it–come at a propitious time. In a few months, national and international data from a second administration of TIMSS in 1999, called TIMSS-R, will be released, followed next spring by data for the 13 states and 14 school districts which will then be able to compare their students' achievement to that of students in other states and in other participating countries. States and districts in every region of the country will have their own TIMSS data against which to benchmark their performance.

The states that participated in TIMSS-R include Connecticut, Idaho, Illinois, Indiana, Maryland, Massachusetts, Michigan, Missouri, North Carolina, Oregon, Pennsylvania, South Carolina and Texas. The participating districts include public school systems in Chicago (IL); Jersey City (NJ); Miami-Dade County (FL); Rochester (NY); and 10 other districts or consortia of districts across the country.

Too often results of international assessments fuel a horse race perception on the part of the public. They are used by the media and others primarily for their messages about competitive rankings. The Minnesota case study, however, provides lessons for states and districts on what they will be able to learn from

TIMSS-R data as to the policies and practices that influence what and how well students learn. NEGP commissioned papers by Senta Raizen, director of the National Center for Improving Science Education; William Schmidt and his colleagues at Michigan State University; and Minnesota educators Frances Lawrenz of the University of Minnesota and SciMathMN Executive Director Bill Linder-Scholer to describe these lessons. Their contributions cover general findings, specific findings about what is taught and how, a synthesis of interviews with math and science educators in the state, and a commentary on how to use the TIMSS data.

Setting the Scene

In 1995, the United States was one of 46 countries participating in the Third International Mathematics and Science Study, the largest such study ever conducted. Results were reported for three levels of schooling: 9-year-olds (grades 3 and 4 in the United States), for 20 countries; 13-year-olds (grades 7 and 8), for 41 countries; and the final year of school (grade 12), for 20 countries. Three states–Minnesota, Colorado, and Illinois–oversampled students in order to obtain a picture of their own students' performance and to secure the rich analysis of curriculum and instructional practices collected by TIMSS, Similarly, several districts in suburban Chicago formed the First in the World Consortium and participated in TIMSS.

Minnesota was the only one of the three states to sample at all grade levels. SciMathMN, a statewide non-profit coalition which sponsored TIMSS in Minnesota (with state funding), "was formed to promote systemic reform of math and science education," according to its executive director, Bill Linder-Scholer. "It just made sense to look at all grades, at the whole system." He estimates the project cost about $350,000.

TIMSS provided the comparison of test scores with the rest of the United States and with those of other countries. As important for policy purposes, however, were the comparisons between math and science achievement within Minnesota.

The Minnesota Results

Generally, Minnesota students' performance in math and science paralleled that of the rest of the United States, with the interesting exception of 8th grade science, where Minnesota students outperformed that of the rest of the country. In mathematics, Minnesota students performed near the international average at all three age/grade levels, slightly above at grades 4 and 8, slightly below at the 12th grade. As compared to students elsewhere in the United States, Minnesota students were on a par with the performance of 4th graders, slightly above that of 8th graders, and outperforming students in this country at the 12th grade. The overall results put the United States and Minnesota in the middle tier of countries on the international assessment at the 4th and 8th grades; Minnesota students stayed in this tier at the 12th grade, while students in the United States as a whole dropped into the lowest tier of countries.

The results for science were different. Minnesota students were outperformed only by students in Korea at 4th grade, and only by Singapore at the 8th grade. By grade 12, their performance fell to just above the international mean. United States students as a whole also did very well at the 4th grade level, the same as those in Minnesota. Eighth-graders in this country, however, ranked in the lowest tier of countries although above the international average. Minnesota students scored 49

points above the international average at the 8th grade, United States students scored 18 points above. By 12th grade, Minnesota students scored only 11 points above the international average, while United States students scored 20 points below.

Among top performing students, much higher percentages of Minnesota students' science scores were at a level considered the top 10 percent of students in all countries (and top quarter) than were the scores in math. The falling off in scores among high achieving students that characterizes the secondary grades in this country begins to manifest itself in 7th and 8th grades.

What the Results Tell

Minnesota officials already were aware that students' math and science achievement compared favorably to that of students in other states. The National Assessment of Educational Progress (NAEP) places Minnesota among the top performing states in math and science. In 1996, 29 percent of its 4th graders scored proficient or higher in math compared to a national average of 21 percent; 34 percent of 8th graders did so, compared to a national average of 24 percent. Improvement between 1990-96 in Minnesota exceeded that of the improvement in the national average for 8th graders. Those achieving proficiency were 23 percent and 15 percent respectively in 1990. In science, the 1996 NAEP tests showed that 37 percent of Minnesota 8th graders scored proficient or higher, compared to 29 percent nationally.

With the contextual understandings provided by TIMSS, Minnesota science and math educators and state/local policymakers sought reasons for the state's exceptionally good performance at 8th grade science.

Among the significant findings of NEGP's case study:

- Because similar students took both the math and science tests—with very different outcomes— the variables usually cited for influencing achievement such as socio-economic status, parents' education, race/ethnicity, and prior achievement, did not account for the difference in performance. Something else was happening.

- The "intended" curriculum in science (what curriculum guides show was meant to be taught) and actual instruction implemented by teachers focused on fewer science topics in grades 1-8 than for the United States as a whole. This is consistent with the patterns in top-achieving other countries. Gains in math, however, followed the usual pattern of instruction in this country, "a mile wide and an inch deep."

What is the National Education Goals Panel?

The National Education Goals Panel is a unique bipartisan body of state and federal officials created in 1990 by President Bush and the nation's Governors to report state and national progress and urge education improvement efforts to reach a set of National Education Goals.

Who serves on the National Education Goals Panel and how are they chosen?

Eight governors, four state legislators, four members of the U.S. Congress, and two members appointed by the President serve on the Goals Panel. Members are appointed by the leadership of the National Governors' Association, the National Conference of State Legislatures, the U.S. Senate and House, and the President.

What does the Goals Panel do?

The Goals Panel has been charged to:

- Report state and national progress toward the National Education Goals.
- Work to establish a system of high academic standards and assessments.
- Identify promising and effective reform strategies.
- Recommend actions for state, federal and local governments to take.
- Build a nationwide, bipartisan consensus to achieve the Goals.

The annual Goals Report and other publications of the Panel are available without charge upon request from the Goals Panel or at its web site www.negp.gov. Publications requests can be made by mail, fax, or e-mail, or by Internet.

They covered many topics without depth, reflecting an unfocused curriculum that often is repeated from grade to grade.

- An important "something else" was a set of "de facto standards" that focused science curriculum for all students, across the state. TIMSS was administered before Minnesota adopted state science standards. Nonetheless, science educators gradually had adopted a sequential curriculum that focused on life science in the 7th grade and earth science in the 8th grade.
- Teachers' use of hands-on instruction can be traced partially to teacher professional development acquired in federally sponsored summer institutes in the 1960s and strong networking and professional norms among Minnesota's science teachers. Teacher content background makes a difference. Among grades 7-12 teachers, 94 percent of Minnesota math teachers had a major in math or math education, as did 97 percent of grades 7-12 science teachers. Comparable percentages for the United States were 72 percent and 74 percent, respectively. Eighth-grade Minnesota students achieved high rankings in earth science; teachers must be certified in earth science in order to teach it in the state.
- Math instruction tended to be more traditional than science instruction. It was textbook-based, while science teachers often favored hands-on, laboratory-based instruction even when this was incongruent with textbook content. Compared to national statistics, Minnesota teachers were half as likely as teachers in the rest of the country to favor prescriptive approaches to doing laboratory experiments.
- Studying the sub-category topics of content, such as decimal fractions and estimation, can help educators detect strengths and weaknesses in the curriculum and trace growth, between either 4th and 8th grades, or 7th and 8th grades. For example, an analysis shows that Minnesota placed among the top-gaining countries in some areas of science at the eighth grade (of the 26 countries which tested both 9- and 13-year-olds, the United States was the only one that did not place among the top-gaining countries in science or math at either grade for any, save one, content area.) Such results, say researchers, reflect a curriculum "that is a mile wide and an inch deep" and one that repeats instruction of the same topics. The pattern in Minnesota is to teach topics for a relatively shorter period of time and then remove them from the curriculum.

THE NATIONAL EDUCATION GOALS

Goal 1: Ready to Learn

Goal 2: School Completion

Goal 3: Student Achievement and Citizenship

Goal 4: Teacher Education and Professional Development

Goal 5: Mathematics and Science

Goal 6: Adult Literacy and Lifelong Learning

Goal 7: Safe, Disciplined and Alochol- and Drug-free Schools

Goal 8: Parental Participation

- Although biology/life science is the curriculum for 7th grade, 8th graders in Minnesota did well on these items in TIMSS, suggesting that the informal decision to make this a focus for the 7th grade created a coherence across the state. According to researchers, the focus and coherent instruction in biology probably led to greater retention–and performance as 8th graders.

- Science performance in 8th grade was probably higher because science students were not tracked. All students received the same curriculum at the 7th and 8th grades. By contrast, math instruction differentiated among students at both the 7th and 8th grades. Students judged to be lower performing were assigned to classes that repeated arithmetic topics and limited these students' access to some of the more advanced math concepts covered by TIMSS for this age group. Also, because of tracking in math, teachers used different textbooks of varying rigor and quality. In science, however, many teachers used the same textbooks which correlated well with the TIMSS items.

- Minnesota's higher performance in science may reflect the stability and continuity of effort in science. The state's math curriculum experienced swings in emphases–between back-to-basics and higher level concepts–for many years The science curriculum, on the other hand, developed in a consistent manner, aided by university, state and professional association leadership.

- At the high school level, Minnesota, like the rest of the United States, offers a layer-cake array of courses in math and science that students can opt out of, if they wish. Four-fifths of Minnesota students, for example, never take any physics course in high school. Even in countries where secondary courses are heavily tracked, all students are still required to take advanced courses, although some may be less rigorous and focused more on application.

TIMSS As a Tool

TIMSS allowed Minnesota state officials, other policymakers, and educators to see that the anomaly of its 8th-grade scores in science could not be explained by all the reasons usually given for differences in student performance. Rather, the reason Minnesota students placed among the best in the world had to do with instruction, especially:

- Uniformly high expectations for all students in science com-

pared to tracking and the resulting curriculum differentiation in math;
- A high degree of focus and coherence in the science curriculum up through grades 8 or 9; and
- A strong alignment of teaching materials, scope and sequence, and instructional strategies in science as compared to math.

Instead of looking for answers in a particular program or "kit," the information from TIMSS suggests, Dr.Linder-Scholer says, "that significant system performance improvements can be achieved by understanding and adjusting the 'expectations' of the system; by providing guidance to practitioners on what to teach, to whom, and the most likely effective methods; and by encouraging alignment" of best practices and other professional norms. These are lessons that can be generalized to states and districts throughout the country, he points out.

TIMSS helped Minnesota science and math instruction avoid a state assessment system that reinforced low expectations. As SciMathMN was analyzing the TIMSS results, the state legislature was approving a high-stakes assessment that emphasized low-level computational skills in math. Because of the data from TIMSS, the test has since been revised to include higher-level skills which other countries expect of their students at the end of the 8th grade.

The information from TIMSS also can guide Minnesota educators toward achieving the state's standards-based reforms. Knowing, for example, that half of the state's 8th graders say they always begin a new topic in science with the teacher explaining the rules and definitions can lead educators to ask better questions about their instruction. The standards call for inquiry-based learning in science. Using what TIMSS tells about classroom practices and students' perceptions can help teachers analyze their instruction and decide how to change.

WAYS TO USE TIMSS TO ADVOCATE FOR STANDARDS-BASED REFORM

- To support the grounding of state standards in a common vision
- To influence the design and deployment of statewide tests
- For guiding development of state curricular standards and frameworks
- To train leadership cadre and statewide leadership infrastructure
- To provide data-based approaches to decisionmaking on local curriculum, instruction, and support schemes
- To guide professional development practice
- To establish a baseline on current practice and to benchmark current practice against world norms
- To link K-12 practice with needed reforms in math and science teacher preparation and development
- To reach parents and engage them in support of standards-based math and science education

Bill Linder-Scholer
Executive Director, SciMathMN

TIMSS can supplement a state's own vision for its students by providing a benchmark for improvements in science and math education. According to Linder-Scholer, the key TIMSS themes–high expectations, focus and coherence, and system alignment–"keep bringing us back to the tough (but helpful) questions about what mathematics and science education should and shouldn't be."

UPCOMING GOALS PANEL EVENTS AND PUBLICATIONS

October 2, 2000 Governor Tommy Thompson hosts an NEGP Field Hearing in Chicago, Illinois, on how the use of data and reporting can help all students achieve to high levels.

Resources:

- *Minnesota & TIMSS: Exploring High Achievement in Eighth Grade Science*, National Education Goals Panel; authors include John Barth, senior education associate at the NEGP; Richard Houang, William Schmidt, and Leland Cogan of the U.S. National Research Center, TIMSS, Michigan State University; Frances Lawrenz, Wallace Professor of Teaching and Learning, Department of Educational Psychology, University of Minnesota; Senta Raizen, Director, National Center for Improving Science Education; and Bill Linder-Scholer, executive director of SciMathMN.

- *Educating Teachers of Science, Mathematics, and Technology: New Practices for the New Millennium*, Committee on Science and Mathematics Teacher Preparation, National Research Council, Washington, D.C.

- National Commission on Mathematics and Science Teaching for the 21st Century (the "Glenn" Commission), final report due this fall; http://www.ed.gov/americacounts

- National Council of Teachers of Mathematics posts information about its standards, including a recent commentary, "How Do States Math Standards Measure Up?" http://www.nctm.org

- Project 2061 of the American Association for the Advancement of Science is a long-term initiative to reform K-12 science education, including standards and community involvement in science education improvement; http://www.project2061.aaas.org

- The National Science Foundation has issued several reports on its Systemic State Initiative to improve math and science education; in July it released a report, "The Learning Curve: What We Are Discovering about U.S. Science and Math Education," based on data through 1995; http://www.nsf.gov

- The Council of Chief State School Officers released *1999 State Indicators of Science and Mathematics Education* in February, 2000. The report was developed through support of the National Science Foundation and in cooperation with the state departments of education. The report is available on line at http://www.ccsso.org